

S. Attal · A. Joye · C.-A. Pillet (Eds.)

Open Quantum Systems III

Recent Developments

 Springer

Contents

Topics in Non-Equilibrium Quantum Statistical Mechanics		
Béatrix Achubischer, Vojkan Jaksic, Tom Prodan, and Claude-Alain Pillet	1	
1	Introduction	2
2	Conceptual Framework	3
3	Mathematical Framework	5
3.1	Basic Concepts	5
3.2	Non-Equilibrium Steady States (NESS) and Entropy Production	8
3.3	Structural Properties	10
3.4	C^* -Scattering and NESS	11
4	Open Quantum Systems	14
4.1	Definition	14
4.2	C^* -Scattering for Open Quantum Systems	15
4.3	The First and Second Law of Thermodynamics	17
4.4	Linear Response Theory	18
4.5	Fermi Golden Rule (FGR) Thermodynamics	22
5	Free Fermi Gas Reservoir	26
5.1	General Description	26
5.2	Examples	30
6	The Simple Electronic Black-Box (SEBB) Model	34
6.1	The Model	34
6.2	The Flusas	36
6.3	The Equivalent Free Fermi Gas	37
6.4	Assumptions	40
7	Thermodynamics of the SEBB Model	43
7.1	Non-Equilibrium Steady States	43
7.2	The Hilbert-Schmidt Condition	44
7.3	The Heat and Charge Flusas	45
7.4	Entropy Production	46
7.5	Equilibrium Correlation Functions	47
7.6	Onsager Relations, Kubo Formulas	49

8	FGR Thermodynamics of the SEBB Model	50
8.1	The Weak Coupling Limit	50
8.2	Historical Digression—Einstein’s Derivation of the Planck Law	53
8.3	FGR Fluxes, Entropy Production and Kubo Formulas	54
8.4	From Microscopic to FGR Thermodynamics	56
9	Appendix	58
9.1	Structural Theorems	58
9.2	The Hilbert-Schmidt Condition	60
	References	63
Fermi Golden Rule and Open Quantum Systems		
<i>José Dereziński and Rafał Frąba</i>		67
1	Introduction	68
1.1	Fermi Golden Rule and Level Shift Operator in an Abstract Setting	68
1.2	Applications of the Fermi Golden Rule to Open Quantum Systems	69
2	Fermi Golden Rule in an Abstract Setting	71
2.1	Notation	71
2.2	Level Shift Operator	72
2.3	LSO for C_0^* -Dynamics	73
2.4	LSO for W^* -Dynamics	74
2.5	LSO in Hilbert Spaces	74
2.6	The Choice of the Projection \mathbb{P}	75
2.7	Three Kinds of the Fermi Golden Rule	75
3	Weak Coupling Limit	77
3.1	Stationary and Time-Dependent Weak Coupling Limit	77
3.2	Proof of the Stationary Weak Coupling Limit	80
3.3	Spectral Averaging	83
3.4	Second Order Asymptotics of Evolution with the First Order Term	85
3.5	Proof of Time Dependent Weak Coupling Limit	87
3.6	Proof of the Coincidence of M_{ex} and M_{loc} with the LSO	88
4	Completely Positive Semigroups	88
4.1	Completely Positive Maps	89
4.2	Stinespring Representation of a Completely Positive Map	89
4.3	Completely Positive Semigroups	90
4.4	Standard Detailed Balance Condition	91
4.5	Detailed Balance Condition in the Sense of Alicki-Frigerio-Gorini-Kossakowski-Narni	93
5	Small Quantum System Interacting with Reservoir	93
5.1	W^* -Algebras	94
5.2	Algebraic Description	95
5.3	Semistandard Representation	95
5.4	Standard Representation	96

6 Two Applications of the Fermi-Golden Rule	
in Open Quantum Systems	97
6.1 LSO for the Reduced Dynamics	97
6.2 LSO for the Liouvillean	99
6.3 Relationship Between the Davies Generator and the LSO for the Liouvillean in Thermal Case	100
6.4 Explicit Formula for the Davies Generator	103
6.5 Explicit Formulas for LSO for the Liouvillean	104
6.6 Identities Using the Fibered Representation	106
7 Fermi-Golden Rule for a Composite Reservoir	108
7.1 LSO for a Sum of Perturbations	108
7.2 Multiple Reservoirs	109
7.3 LSO for the Reduced Dynamics in the Case of a Composite Reservoir	110
7.4 LSO for the Liouvillean in the Case of a Composite Reservoir	111
A Appendix – One-Parameter Semigroups	112
References	115

Decoherence as Irreversible Dynamical Process in Open Quantum Systems

<i>Philippe Blanchard, Robert Olneige</i>	117
1 Physical and Mathematical Prologue	118
1.1 Physical Background	118
1.2 Environmental Decoherence	119
1.3 Algebraic Framework	120
1.4 Quantum Dynamical Semigroups	121
1.5 A Model of a Discrete Pointer Basis	123
2 The Asymptotic Decomposition of T	126
2.1 Notation	126
2.2 Dynamics in the Markovian Regime	127
2.3 The Unitary Decomposition of T_{ε}	130
2.4 The Isometric-Sweeping Decomposition	133
2.5 Remarks	135
3 Review of Decoherence Effects in Infinite Spin Systems	138
3.1 Infinite Spin Systems	138
3.2 Continuous Pointer States [10]	139
3.3 Decoherence-Induced Spin Algebra [6]	143
3.4 From Quantum to Classical Dynamical Systems [38]	146
4 Dynamical Semigroups on CCR Algebras	148
4.1 Algebras of Canonical Commutation Relations (CCR)	148
4.2 Pmeasures on Locally Convex Topological Vector Spaces	149
4.3 Perturbed Convolution Semigroups of Pmeasures	151
4.4 Quantum Dynamical Semigroups on CCR Algebras	153
4.5 Example: Quantum Brownian Motion	155
5 Outlook	157

References	158
Notes on the Qualitative Behaviour of Quantum Markov Semigroups	
<i>François Fagnola and Roland Rebentrost</i>	161
1 Introduction	162
1.1 Preliminaries	164
2 Ergodic Theorems	165
3 The Minimal Quantum Dynamical Semigroup	167
4 The Existence of Stationary States	172
4.1 A General Result	172
4.2 Conditions on the Generator	174
4.3 Examples	178
4.4 A Multimode Dicke Laser Model	178
4.5 A Quantum Model of Absorption and Stimulated Emission	182
4.6 The Jaynes-Cummings Model	183
5 Faithful Stationary States and Irreducibility	184
5.1 The Support of an Invariant State	184
5.2 Subharmonic Projections, The Case $\mathfrak{M} = \mathcal{L}(\mathbb{H})$	186
5.3 Examples	188
6 The Convergence Towards the Equilibrium	189
6.1 Main Results	190
6.2 Examples	192
7 Recurrence and Transience of Quantum Markov Semigroups	194
7.1 Potential	194
7.2 Defining Recurrence and Transience	198
7.3 The Behavior of a d -Harmonic Oscillator	201
References	203
Continual Measurements in Quantum Mechanics and Quantum Stochastic Calculus	
<i>Alberto Barchielli</i>	207
1 Introduction	208
1.1 Three Approaches to Continual Measurements	208
1.2 Quantum Stochastic Calculus and Quantum Optics	208
1.3 Some Notations: Operator Spaces	209
2 Unitary Evolution and States	210
2.1 Quantum Stochastic Calculus	210
2.2 The Unitary System-Field Evolution	217
2.3 The System-Field State	223
2.4 The Reduced Dynamics	225
2.5 Physical Basis of the Use of QSC	228
3 Continual Measurements	230
3.1 Indirect Measurements on $S_{\mathbb{H}}$	230
3.2 Characteristic Functionals	233
3.3 The Reduced Description	241

3.4. Direct Detection	247
3.5. Optical Heterodyne Detection	252
3.6. Physical Models	257
4. A Three-Level Atom and the Shelving Effect	258
4.1. The Atom-Field Dynamics	259
4.2. The Detection Process	262
4.3. Bright and Dark Periods: The V-Configuration	264
4.4. Bright and Dark Periods: The A-Configuration	267
5. A Two-Level Atom and the Spectrum of the Fluorescence Light	269
5.1. The Dynamical Model	270
5.2. The Master Equation and the Equilibrium State	274
5.3. The Detection Scheme	277
5.4. The Fluorescence Spectrum	282
References	288
Index of Volume III	293
Information about the other two volumes	297
Contents of Volume I	298
Index of Volume I	302
Contents of Volume II	306
Index of Volume II	309